Advanced Structures and Materials

Engineering Directorate Technology Thrust Area

Marshall Space Flight Center (MSFC) • Huntsville, Alabama

Advanced Structures and Materials is a high emphasis technology activity of the MSFC Engineering Directorate. Experts of both disciplines are working together to develop an advanced structures and materials technology plan for the directorate. Through strategic planning and partnerships with industry, academia, and other NASA centers, this team aims to develop advanced structures and materials applications to meet tomorrow's space flight hardware needs.

CMC Blisk Material Development and Testing

Radiation Cooled Thrust Chamber Material Development

Cooled CMC Panel Material and Design Development

Technology Spotlight

Thin Film Structures

Engineers at MSFC are developing fabrication processes and designs for ceramic matrix composite (CMC) components through material and component testing, structural modeling, microscopy, and nondestructive analysis techniques. CMCs will be utilized extensively on future generation launch vehicles for propulsion systems and for vehicle hot structure. They are necessary to enable lightweight components capable of operating over a wide temperature range. These advantages translate into increased safety and lower cost compared to state-of-the-art materials. MSFC is primarily responsible for developing CMCs and transitioning them into propulsion applications such as cooled and radiation cooled flow paths, thrust chambers, integrally bladed disks (blisks) and nozzles. Hot structures for leading edge and control surface applications are also supported.

Development of CMCs and their transition into launch vehicle applications is coordinated with efforts at other NASA center, government agencies, industry, and academia. Fabrication and material development is mainly through contracts to material vendors to develop processes and materials that are best suited to NASA's needs. MSFC conducts extensive material and component analysis with microscopy and nondestructive evaluation (NDE) to determine the CMC's integrity with respect to processing and post-test results. The NDE is used in conjunction with destructive testing to resolve material processing, property, and operational behavior relationships. Much of the initial, small scale, CMC component development effort is performed at the Glenn Research Center. Once CMC components are proven at the smaller sizes, large scale testing is envisioned in existing test stands at MSFC.

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Additional Advanced Structures and Materials Technologies

Advanced Metals and Metal Matrix Composites Applications

Subscale MMC Lox Turbopump Housing

Advances in metals and process technology are required to meet the demanding requirements of next generation space flight structures. Engineers at MSFC are developing next generationmetals to achieve increased performance through reduced weight, increased environmental capability, reduced manufacturing cost, and longer life. Metal matrix composites are strong candidates for aerospace applications such as turbopump and turbine housing, main combustion chambers, ducts, flanges, and valves. These materials offer advantages of high specific strength and stiffness, lower coefficient of thermal expansion, environment compatibility similar to metals, ductility and toughness from the metal matrix, and others.

Polymer Matrix Composites Applications

Polymer matrix composites (PMCs) are a lightweight, high performance alternative to traditional metallic designs for a wide range of applications. They offer potential benefits in space transportation applications such as feedlines and valves, engine thrust chamber assemblies, and turbopump housings. They are also advantageous for applications such as advanced telescopes/optical benches with tailored thermal expansion trusses and tubes. Engineers at MSFC are developing, modeling, and testing polymer matrix composite structures for a range of applications. Working together with engineers from industry, academia, and other NASA centers, MSFC engineers aim to develop new applications for PMCs to meet the demanding requirements of space flight hardware.

Advanced Structural Analysis Tools and Methodologies

As new, advanced materials are developed for use in tomorrow's space transportation systems, new structural analysis tools must be developed and validated for use in design. These tools must enable engineers to analyze proposed designs and predict their performance under the hostile environments associated with space travel. Engineers at MSFC are working together with other NASA centers, industry, and academi to develop and implement advanced structural analysis tools. For example, tools under development to more accurately predict the development and growth of cracks in engine components such as single-crystal metallic turbine blades. Anaysis tools such as these will enable revolutionary designs that will be less likely to require expensive redesigns.

Thin Film Structures

Thin Film Structures Testing at MSFC

Engineers at MSFC are developing, testing, modeling, and analyzing thin film structures. These lightweight and inflatable structures may one day lead to optical, solar power, or propulsion uses in space.

Thin film structures are composed of compact, thin-walled membranes. This technology holds the promise of being used for very large structures in the weightlessness of space at reduced cost. These forms would weigh a fraction of traditional metal and composite constructions and when deflated, could be packed into a much smaller volume - making them much cheaper to launch.

MSFC engineers and university researchers are also developing methods for rigidizing (hardening) thin-film inflatable structures to ensure long-term survival in the orbital environment.